Disclaimer: The views expressed are those of Paul Gipe and are not necessarily those of the sponsor.

Disclosure: Paul Gipe has worked with Aerovironment, ANZSES, An Environmental Trust, APROMA, ASES, AusWEA, AWEA, David Blittersdorf, Jan & David Blittersdorf Foundation, BWEA, BWE, CanWEA, Canadian Co-operative Assoc., CAW, CEERT, Deutsche Bank, DGW, DSF, EECA, ES&T, GEO, GPI Atlantic, IREQ, KWEA, MADE, Microsoft, ManSEA, MSU, NRCan, NRG Systems, NASA, NREL, NZWEA, ORWWG, OSEA, Pembina, PG&E, SeaWest, SEI, TREC, USDOE, WAWWG, WE Energies, the Folkecenter, the Izaak Walton League, the Minnesota Project, the Sierra Club, World Future Council, and Zond Systems, and written for magazines in the USA, Canada, France, Denmark, and Germany.

Paul Gipe, wind-works.org
The Long & Winding Road to Today’s Small Wind Industry

By

Paul Gipe
Back In the Mists of Time

The Beginning

130 Years of Wind Generation
Brush Dynamo

- Upwind
- Self-Regulating
- DC w/ Batteries

1888, Charles Brush, Cleveland, Ohio

© Western Reserve Historical Society

Paul Gipe, wind-works.org
Poul La Cour

- Active Yaw
- Upwind
- Self-Regulating
- DC w/ Batteries
- Later Hydrogen

1891, Askov, Denmark

© Poul La Cour Fonden
Paul Gipe, wind-works.org
FL Smidth Aeromotor

- 3-Blades
- Upwind
- Active Yaw
- AC
- Interconnected

1944, Skagen, Denmark

© Danmarks Vindkrafthistoriske Samling
Paul Gipe, wind-works.org
Wind Well Known by 1920s
Certainly by 1950s

- 1919 First Interconnected (DK)
- Early 1920s La Cour (DK)
- 1925 Darrieus (F)
- 1927 Betz (DE)
- 1928 Betz (in English)
- 1940 Hütter (DE), Putnam (USA)
- 1955 Golding (GB)
- 1957 Vadot (F)

Paul Gipe, wind-works.org
Smith-Putnam 1.25 MW, 1941
53 m, Downwind, ~700 hrs
Growian
100 m, 3 MW, Downwind, 1981
~400 hrs
Kaiser-Wilhelm Koog, Germany
Paul Gipe, wind-works.org
Gedser—The Godfather

- 1957-67, & 1978 (US DOE)
- 3-Blades
- Upwind, Active Yaw
- Pitchable Blade Tips
Twind
54 m, ~1 MW
1978-Present!

© T vind kraft

Paul Gipe, wind-works.org

2012, Denmark
Those Crazy Danes

The Grasshopper

1980, Risø Test Station
Roskilde, Denmark

Paul Gipe, wind-works.org
Crazy Danes—VAWTs Too

- Giromill
- Generator at Ground Level

1980, Risø Test Station
Roskilde, Denmark

Paul Gipe, wind-works.org
Crazy Danes--Vestas

Yes, That Vestas

1980, Lem, Denmark

Paul Gipe, wind-works.org
Crazy Danes--Jydsk Vindkraft

- 3-Blades
- Downwind
- Passive Yaw

Modern!

1980, Risø Test Station
Roskilde, Denmark

Paul Gipe, wind-works.org
Meanwhile
In a Land Far Away
Riding the Wind—Into an Industry

~1975-1976, Wind-King, Southeastern Montana

Don’t try this at home!

Paul Gipe, wind-works.org
In the Beginning--There Was Salvage

~1976, Southeastern Montana

Dave Ellis, Wind Cowboy

Jacobs

Paul Gipe, wind-works.org
Salvage Machines

• Abundant
• Cheap
• Worked

Especially Jacobs

Paul Gipe, wind-works.org
Wincharger Most Abundant of All

Two blades pitching, two blades fixed & furling

Mormon Point, Grand Teton NP

Paul Gipe, wind-works.org
Parris-Dunn Vertical Furling

~1976, Reconditioned, Location long forgotten.

Paul Gipe, wind-works.org
Jacobs Direct Drive DC Generator
Jacobs Pitching & Furling

1979, Reconditioned, WTSU, Canyon, Texas.

Ken Starcher

Paul Gipe, wind-works.org
Then Purpose-Built Turbines

Late 1970s-Early 1980s, Fayette, Dubois, Pennsylvania
Forerunner of Fayette 95 (?)

Paul Gipe, wind-works.org
Blast from the Past: UMASS

Late 1970s, UMASS Wind Furnace
Forerunner of US Windpower 56-50

Paul Gipe, wind-works.org
Terry Mehrkam

Late 1970s-Early 1980s,
Hamburg, Pennsylvania
Killed 1981

Paul Gipe, wind-works.org
Where Small Wind Stands

• Been There--Done That
  VAWTs, DAWTs, & More
• Lessons Learned
• Where Do We Stand Now
• Future
  Cyclic Industry
  New Markets-New Niches
  New Players—They See Opportunity

Paul Gipe, wind-works.org

2008, Skystream,
Alexandria, Indiana
Been There—Done That: VAWTs

HAWT

VAWT

Paul Gipe & Assoc.
VAWT Configurations

“H”  DELTA  DIAMOND  “Y”  PHI

Paul Gipe, wind-works.org
VAWTS Omnidirectional? Sure—But So Are HAWTs

Paul Gipe, wind-works.org
VAWTs
Drag Devices (Paddles)

Paul Gipe, wind-works.org

~1930s, Texas Tech Museum
Savonius or “S” Rotors

2013, Indianapolis, Indiana
Cantilevered Darrieus

~1981, Alcoa 10 kW, Somerset, Pennsylvania

Paul Gipe, wind-works.org
VAWTs

Darrieus

2 Blades

~1979 Installed, DAF-Indal
Atlantic Wind Test Site, PEI

Paul Gipe, wind-works.org
VAWTs
♀ Darrieus
4 Blades

~Late 1980s, Adecon, Pincher Creek, Alberta

Paul Gipe, wind-works.org
Giromills
Articulating Straight Blade VAWT

Paul Gipe, wind-works.org
Giromill

Articulating Straight Blade VAWT

Paul Gipe, wind-works.org
Giromill (McDonnell Aircraft)

Paul Gipe, wind-works.org
Giromill (McDonnell Aircraft)

- High Hype
- As Good as Betz
- Complex
- Costly
- DOE Boondoggle
Variable Geometry VAWT (Musgrove)
Cleaning Up After Cleanfield

• Early 2000s
• Student Project!
• Wind Tunnel Tests
• Volts—No Amps

Paul Gipe, wind-works.org
Cleaning Up After Cleanfield

- 2007 Still No Testing
- 2009 A “Success” by OCE
  OCE: a Dumping Ground for Tory Politicians
- After a Decade Still No Results
- 2013 Defaults on $1.3 Mil Loan

Paul Gipe, wind-works.org
VAWTs Magnet for Hustlers & Charlatans

- Pyramidal Power
- Celebrity Endorsers
  Jay Leno, Ed Begley
- Globe & Mail
  Next Alexander Graham Bell
- More Energy than in the Wind

Magwind, Whitby Ontario

Paul Gipe, wind-works.org
Lanchester-Betz Limit

Betz Limit

3 Bladed HAWT

2 Bladed HAWT

Darrieus VAWT

Φ-Configuration Darrieus

Power Coefficient

Tip Speed Ratio

American Multi-blade Windmill (HAWT)

Dutch Windmill (HAWT)
Bergey’s VAWT

Yes, That Bergey

1979, Mike Bergey

Paul Gipe, wind-works.org

© Bergey Windpower
**VAWT-HAWT Poor Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Swept Area (m²)</th>
<th>Tested Power (kW)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UGE VAWT</td>
<td>16.6</td>
<td>1.5</td>
<td>756</td>
</tr>
<tr>
<td>Bergey 6</td>
<td>30</td>
<td>5.5</td>
<td>350</td>
</tr>
</tbody>
</table>

Just a little background—summary stats.

Paul Gipe, wind-works.org
VAWT-HAWT Poor Comparison

- HAWT 2X Effec.
- HAWT ¼ Specific Mass
- HAWT Self-Regulating

Tested to IEC 61400-12-1

Paul Gipe, wind-works.org
FloWind’s Generation in California

The World’s Most Successful VAWT

Million kWh/yr

Year


Paul Gipe, wind-works.org
Those Who Don’t Build VAWTs

- Adecon
- Alcoa
- Bergey Windpower
- Bristol Aerospace
- DAF-Indal
- Herman Drees
- Dornier
- FloWind
- Heidelberger
- Sir Robert McAlpine
- McDonnell Aircraft
- Vestas
- . . . and Many More

Paul Gipe, wind-works.org
VAWTs

- Less Power
- Not Self-Regulating
- More Mass
- More Expensive
- Why Bother?

Paul Gipe, wind-works.org

Late 1980s, Windmill-Wildflower Hike
Monsieur Darrieus & His Invention

- $\phi$ Rotor
- H-Rotor
- Giromill
- In Wind
- In Water

Paul Gipe, wind-works.org
Monsieur Darrieus & His Invention

- Patent Filed 1926, Granted 1931
- 1927: 8 m dia HAWT
- 1929: 20 m dia HAWT
- 1930: 10 m dia HAWT
- 1944: H-Rotor Wind Tunnel Model
- **Darrieus Never Built a Darrieus!**
VAWTs
Are the Energy Source of the Future
and
They Always Will be
--Mark Mayhew
Been There—Done That: DAWTs

Paul Gipe, wind-works.org 2015, Ogin, Antelope Valley, California
DAWTs—Old as the Hills at Least the California Hills Just as Questionable Then as Now

1927, Dew Olliver’s Blunderbuss, San Gorgonio Pass
Diffuser Augmented Wind Turbines
DAWTs or Ducted Turbines

2005, Enflo, Germany

1997-2001, Vortec, New Zealand

Paul Gipe, wind-works.org
Mon Dieu! Elena Doubling Down

- Double Diffusers--Double Rotors
- Contra-Rotating
- ~2-4 Times Betz Limit
- ~10 Times Rational

Paul Gipe, wind-works.org
Maison de l’Air Poisson d’Avril?

2010, Elena 30, Paris
Diffuser Augmented Small Wind Turbines
Elena 30 ~10X Maximum Conceivable

Paul Gipe, wind-works.org
Diffuser Augmented Small Wind Turbines

Elena 30: 2-4 X Betz Limit

Paul Gipe, wind-works.org
Politicians Love DAWTs & VAWTs

• Anything to Avoid Serious Decisions
• Denis Baupin, Maire-adjoint (Verts)
  “. . . nous ne souhaitons pas deteriorer son paysage” (We don’t wish to spoil the Paris cityscape)
• . . . with Real Wind Turbines!

Paul Gipe, wind-works.org
Honeywell Windtronics?

Paul Gipe, wind-works.org
Honeywell Windtronics?

• It’s a Bicycle Wheel!

Paul Gipe, wind-works.org
Windtronics: An Example

• Creating Strawmen—to Knock Down

Most Small Wind Turbines Use Direct Drive—Not Gearboxes!

Paul Gipe, wind-works.org
Windtronics: An Example

• Creating Strawmen--to Knock Down

How to redesign a turbine to start at 0.5 (1/2) mph

By practically eliminating mechanical resistance and drag, the Honeywell Wind Turbine project teams designed the Honeywell Wind Turbine. The Honeywell Wind Turbine is DTBG

• There is No Energy in the Wind @ 2 mph
• Who Cares if it Turns @ 2 mph?
• If You Want a Kinetic Sculpture
  “Buy a Whirligig”--They’re Much Cheaper

Mick Sagrillo

Paul Gipe, wind-works.org
Windtronics: An Example

• Makes Claim to Big Endorsement

Honeywell

• But, Read the Fine Print

The Honeywell Trademark is used under license from Honeywell International Inc. Honeywell International Inc. makes no representation or warranties with respect to this product.

• Honeywell Licenses Name Only

Paul Gipe, wind-works.org
Windtronics: An Example

- **Energy Generation?**
  What Does This Really Mean?
  
  $2,752 \text{ kWh/yr maximum output constant wind (Class 4 DOE)}$

- **2,800 kWh/yr in Class 4?**
  2.4 X Realistic Estimate

- **Is “Constant” Wind the Answer?**
Windtronics: An Example

• No Testing, No Certification

  [Image of a certificate]
  **Product Certification**
  ETL listed, conforming to UL 1741 and CAN/CSA C22.2 No.107.1.

• Misleading the Unsophisticated

  UL/CSA Certifies Only the Electrical Components
  Not the Wind Turbine as a Wind turbine

Paul Gipe, wind-works.org
Windtronics: An Example

- Did Not Apply to be Certified

<table>
<thead>
<tr>
<th>Applicant</th>
<th>Turbine</th>
<th>Under Contract</th>
<th>Under Test</th>
<th>Reports Submitted</th>
<th>Certification Granted</th>
<th>Certification Number</th>
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</thead>
<tbody>
<tr>
<td>American Zephyr Corporation</td>
<td>Airdolphins GTO</td>
<td>5/20/10</td>
<td>2/12/10</td>
<td></td>
<td>Application Pending</td>
<td></td>
</tr>
<tr>
<td>Bergey Windpower Co.</td>
<td>Bergey 5kW</td>
<td>5/27/10</td>
<td>4/14/11</td>
<td></td>
<td>Application Pending</td>
<td></td>
</tr>
<tr>
<td>Bergey Windpower Co.</td>
<td>Bergey Excel-S</td>
<td>6/15/10</td>
<td>6/24/10</td>
<td></td>
<td>Application Pending</td>
<td></td>
</tr>
</tbody>
</table>

- Windtronics Not Listed
Honeywell Windtronics 2008-2013

- Hoodwinked State of Michigan
- Hoodwinked Province of Ontario
  $2.7 million
- Hoodwinked Ace Hardware
- Need One?

Paul Gipe, wind-works.org
SheerWind-Invelox DAWT

• Nature Conservancy
  “Won’t Kill Birds...”
• Michigan National Guard
  3 of Them!
• Denmark “Chimney”
• “Constant Wind” Again

Paul Gipe, wind-works.org

Wikimedia Commons
Are DAWTs Dead?

2016, Ogin, Palm Springs

Paul Gipe, wind-works.org
FloDesign-Ogin & the Big Boys

- Kleiner Perkins VCs
  - Al Gore, Arpa (DOE), MIT . . .
- Alberta & NZ Pension Funds
- $300 million?
  - 10 Times that of Vortec
- On Life Support?
- The Walking Dead?

Paul Gipe, wind-works.org
Zombie Wind
DAWTs from the Grave

- Honeywell Windtronics—Tam Energy
- FloDesign-Ogin—Is it Really Dead?

Paul Gipe, wind-works.org
The Problem with DAWTs

• Shrouds Are Expensive
• No High Wind Protection
  Tower & Foundation
• Always Underperforms Projections
• No Real Advantage
• Yeah, Ok, It’s Different . . .

Paul Gipe, wind-works.org
Rooftop Wind: Why Bother?

- It is Where the People Live
- Solar PV **Was** Expensive
  Wind **Was** Cheaper than Solar PV
- Tall Buildings--No Tower Needed
  Wrong!

Paul Gipe, wind-works.org
Roof Top Mounting?

- Turbulence
- Poor Performance
  ~0 Net Energy!
- Noise & Vibration
- Safety
- Simply a Bad Idea

Paul Gipe, wind-works.org

Dublin, circa 1990s
Oh, This Isn’t Going to Work!

1979, St. Eleanors, Prince Edward Island

Paul Gipe, wind-works.org
Roof Top Mounting

- Allgaier (1950s)
- Tied Off

Similar installation along main rail line near Bonn. Also tied off.
Roof Top Turbine
Toronto

Only Works in Animation on a Web Site

Paul Gipe, wind-works.org
Roof Top Mounting?

Renewable Energy Devices Swift

Hugh Piggott, Scoraig Wind Electric
Roof Top Mounting?

- Tied Off

Paul Gipe, wind-works.org
Roof Top Mounting?

- Tied Off

Paul Gipe, wind-works.org
Montreal’s Biosphere: 2x2 kW?

Paul Gipe, wind-works.org
Montreal’s Biosphere: 2x2 kW?

Paul Gipe, wind-works.org
Boston Museum of Science Rooftop Wind Test Site

- Most Thorough Testing in US
- Downwind, Upwind, & VAWT
- 5 Models
- Full Power Curves & Scatter Plots
- Performance Metric: kWh/m²
- Average Wind Speed: 3-3.7 m/s

Paul Gipe, wind-works.org
Boston MoS Rooftop Wind Test Site
Lessons Learned after Two Years

• No Issue with Noise, Vibration, Ice Throw, Flicker, Bats, Or Neighbors
• 1 Bird Killed (Red-tail Hawk)
• Several Turbines “Underperforming”
• “Not Cost-Effective at This Site”

Paul Gipe, wind-works.org
Boston MoS Rooftop Wind Test Site Lessons Learned

• Be Clear on Goals
  Energy, Economics, Education?
• Seek Input “Early & Often”
• Rooftop May Compromise Siting, Duh!
• Wind is More than Just a Wind Turbine
  Inverter-Turbine Package
  Tower, Structural Support
  Interconnection

Paul Gipe, wind-works.org
Boston MoS Rooftop Wind Test Site Lessons Learned

<table>
<thead>
<tr>
<th></th>
<th>kWh/yr</th>
<th>kWh/m²</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Skystream</td>
<td>1,500</td>
<td>140</td>
<td>Performing as Expected</td>
</tr>
<tr>
<td>Proven</td>
<td>2,200</td>
<td>100</td>
<td>Underperforming</td>
</tr>
<tr>
<td>Aerovironment</td>
<td>500</td>
<td>40</td>
<td>Underperforming</td>
</tr>
<tr>
<td>Swift</td>
<td>100</td>
<td>30</td>
<td>Poor Site</td>
</tr>
<tr>
<td>Windspire</td>
<td>175</td>
<td>23</td>
<td>Underperforming</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
<table>
<thead>
<tr>
<th>Model</th>
<th>kWh/m²</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull V47</td>
<td>900</td>
<td>Conventional</td>
</tr>
<tr>
<td>Hull V80</td>
<td>753</td>
<td>Conventional</td>
</tr>
<tr>
<td>IBEW NPS 100</td>
<td>231</td>
<td>Conventional</td>
</tr>
<tr>
<td>Skystream</td>
<td>140</td>
<td>Rooftop</td>
</tr>
<tr>
<td>Proven</td>
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</tbody>
</table>
Building Integrated & Rooftop Wind? A Failure Says NREL—Sort of

• Experience Mixed Results—Really?
• Success Defined as
  Meeting their PR Objectives. . .
  Most “Successful” Project: 12 West
  $240,000 for 4 Skystreams on 45-foot Towers
  $30,000/kW
  $44/kWh—100 X of Commercial Wind
  Only Project Where the Turbines Operated Reliably!

Paul Gipe, wind-works.org
Urban Wind: What is It?

- Rooftop Wind Turbines
- Poorly Sited Wind Turbines
- Mostly Architectural Greenwashing
- Indianapolis: Ground Zero

Paul Gipe, wind-works.org
Greenwashing: What Is It?

• Make Believe Wind
• Fake, Deceptive—a Sham, Phony
• PR Value Exceeds Energy Generation
  Mining LEED Points
• “Kinetic Sculptures”
  Sometimes Not Even That!
• Often “Not Like Those Other” Turbines

Paul Gipe, wind-works.org
Urban Wind: Mariah (KIB)

LEED Points for Keep Indianapolis Beautiful

Possibly Not Even Kinetic Sculpture

Paul Gipe, wind-works.org
Indiana Nature Conservancy

- “Crown Jewell” (Architectural Bling)
- $30,000
- “Might Not Generate 8,000 kWh/yr”
- They Got That Right!

Paul Gipe, wind-works.org